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Monitoring water content in highly-clayey soils: calibration, temperature dependence and field use of "WCR" probes.

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Measurement of the soil water content is an essential step in the understanding of the hydrodynamic behaviour of a soil. Amongst the available methods for soil moisture measurements, dielectric methods (eg WCR Campbell Scientific) are probably the most widely used nowadays. WCR CS 615 and 616 probes have been set up in the ORE Draix (SE French Alps) for _8 years to measure soil water content in soft clay shales.
The continuous monitoring carried out during two years (time step measurement of 10-15 min) showed two critical points:
- The water contents were highly overestimated when the manufacturer calibration equation was used
- Measurements showed well-marked daily oscillations, according to soil temperature variations.
This phenomenon is likely to come from the specific mineralogical characteristics of the soils. They are characterized by high contents of clays (up to 40 % of illite / smectite). Recent work (Stangl et al, 2009) showed similar measure difficulties for clay soils and they pointed out the need to propose a specific calibration for such material.
In order to improve the soil water content assessment, a laboratory calibration for CS616 WCR probes was initiated. The measurements were performed under controlled water content and temperature conditions. A first series of tests was carried out at saturation water content using columns filled with black marls from the Draix experimental site. The results were used to evaluate more properly the water content at saturation and quantify the effects of temperature on the WCR probes response.
A second series of tests was performed on four types of marl from sites located in the Southern Alps (La Valette and Boulc Mondores landslides) and on a silty clay soil. These media have different characteristics in terms of weathering, type of clay and cation exchange capacity. The materials collected were reworked (grinding and sieving to 2 mm) to obtain material with similar structure. These tests were used to quantify the influence of the mineralogical characteristics of the materials on the WCR measurements and propose a specific calibration curve for each material.
All the tests have clearly demonstrated that the temperature dependence of the sensor response was significantly greater than that announced by the manufacturer.
We propose a method for correcting the effects of temperature based on the use of field recordings. This method requires that each probe WCR should be combined with a temperature sensor. The proposed technique has the advantage of avoiding laboratory testing. However, correcting the effects of temperature does not remove completely the daily oscillations, and we encountered difficulties to automate the method of correction.
In conclusion, we recommend to users of WCR sensors in a clayey medium to associate field measurements of water content with temperature recording, so that it is possible to correct the effects of the temperature dependence. An optimal calibration of sensors can be obtained only through laboratory tests. However, it seems possible, using some in-situ measurements, to adapt to other sites the calibration curves that we obtained.